European Global Product Realisation
Creativity and Innovation in Educating Engineers and Product Designers of 21st Century

Kovacevic, Ahmed ; Duhovnik, Jozef ; Horvath, Imre; Marjanovic, Dorian; Horák, Péter

DOI
10.1007/978-3-031-50488-4_6

Publication date
2024

Document Version
Final published version

Published in
Design Research: The Sociotechnical Aspects of Quality, Creativity, and Innovation

Chapter 6
European Global Product Realisation: Creativity and Innovation in Educating Engineers and Product Designers of 21st Century

Ahmed Kovacevic, Jozef Duhovnik, Imre Horváth, Dorian Marjanović, and Péter Horák

Abstract COllaborative DEsign in Virtual Environment (CODEVE) is a teaching methodology developed within the European Global Product Realization (EGPR) course over a number of years. Today's products are global and our students engage in their early professional practice facing challenges of working within distributed organisations to develop global products. Following early research on methods and tools in educating students for such challenges, the Global Product realisation course was initiated at the dawn of 21st Century and was performed since then as a collaboration between European Universities. Each year, an Academic Virtual Enterprise of participating Universities and an Industrial partner is formed in which students are distributed in international teams formed from multiple partner Universities. Educational activities and the project tasks are primarily communicated through videoconferencing and other synchronous and asynchronous means of communication. The design process model applied in CODEVE originates from the model of Pahl and Beitz, but is extended and adapted to suit the fuzzy front end of design projects performed in academic virtual enterprises. The extensions are related to creating a vision and implementing design research methodologies at the start of the project, blending phases of embodiment and detail design as well as bringing students for the first time in the final workshop which is aimed to culminate with the working

A. Kovacevic (✉)
City, University of London, London, England, UK
e-mail: a.kovacevic@city.ac.uk

J. Duhovnik
University of Ljubljana, Ljubljana, Slovenia

I. Horváth
Delft University of Technology, Delft, Netherlands

D. Marjanović
University of Zagreb Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia

P. Horák
Budapest University of Technology and Economics, Budapest, Hungary

D. Marjanović et al. (eds.), *Design Research: The Sociotechnical Aspects of Quality, Creativity, and Innovation*, https://doi.org/10.1007/978-3-031-50488-4_6

prototype and public presentations of the products. The CODEVE methodology was tested on projects which include design of consumer products, service driven products and industrial machinery. The evaluation of the methodology was supported by the Erasmus + funded project called Networked Activities for Realization of Innovative Products (NARIP) from 2015–2017.

The CODEVE teaching methodology enables students to work on an industrial project, it encourages them to understand and explore methods from other disciplines and helps them to overcome barriers of distributed environment. Similarly, they realise that communication style, relationships with teammates, and the availability and clarity of shared information play a crucial role in the realisation of the project.

The CODEVE methodology has been implemented in academic institutions in Europe and tested in both European and transatlantic projects with Universities from Europe and America. This chapter outlines advantages and challenges in conducting this type of educational projects including the influence of the selection of product, industrial partners, marketing, implementation etc.

6.1 Introduction

In this rapidly changing world, the future of many companies depends on globalisation of design, manufacturing, servicing and sales. A study published in March 2006 (Spinks et al., 2006) outlines an industrial view on what engineers who will operate in this century should be. The main message of the report can be summarised as; *"… At the heart the defining and enabling skills that form the core competencies of the engineering graduate… Three roles are identified. Firstly the role of engineer as specialist … Secondly, the engineer as integrator reflects the need for graduates who can operate and manage across boundaries, be they technical or organisational, in a complex business environment. Thirdly,…the critical role engineering graduates must play is providing the creativity, innovation, and leadership needed to guide the industry to a successful future. This is a vision of the future that underlines the vital importance of undergraduate engineering education to the UK engineering industry…".*

Two distinctive views on the development of these competences can be identified. The first, often referred to as the reductionist view, assumes that design competence is nothing other than a set of basic design abilities typically addressed individually. The opposite is the holistic view, which sees design competence as a synergetic construct of generic human capacities, as explained by (Horváth, 2006). Various authors argue that design competences are built in different contexts (Bourgeois, 2002). In the past, the emphasis was put on getting basic knowledge for a designer to possess and use. At that time, students were taught in a way which helped them to pass examinations rather then to solve successfully real life design problems. Recently, however, design problem solving capabilities have been given growing attention and various aspects of design competence have been investigated and addressed. Many authors analysed which industrial and pedagogical requirements of competences students should have and how to obtain these in university engineering design courses. Munch and Jakobsen (2005) identified the three most important characteristics of competence namely, contextual, behavioural and problem oriented. They argue that there is no universal deliverable for engineering design education but rather that specific design know-how should be conveyed to students depending on the goals, content and form of a design.

The competence development is normally assessed in terms of its operation to enable design problem solving. For instance, (Crain et al., 1995), put these in categories such as teamwork, information gathering, problem definition, idea generation, evaluation and decision making, implementation, and communication. The authors claim that these should be developed within introductory design courses and suggest that other competences are to be addressed in higher design courses to suit specific disciplines. In all cases, knowledge remains important, but it is more often considered as an element of engineering design know-how, rather than as the only goal of design education. Overbeeke et al. (2004), identified nine competences that need to be developed by industrial design engineering education, and grouped these as core and meta competences. Horváth (2006), analysed the connection between personal know how and that contained in a community of professionals. Berge et al. (2002) concluded that communal competences are becoming more important for industry nowadays. Typically, communal competences are multi-disciplinary collaboration, dislocated communication, balanced comprehension, and resource sharing, while personal competences are creativity, communication, integrative thinking, problem solving and learning from examples.

The organisers of the European Global Product Realisation (EGPR) course did recognise the importance of the above requirements and hence adopted and followed a holistic view on engineering design education. A comprehensive review of the research performed during the previous courses on the development of holistic design competences is reported in (Horváth, 2006), Based on the experience and publications, the organisers of the course adopted the view that design competence is a combination of five capacities. These are knowledge, skills, capabilities, attitude, and experience, as shown in Fig. 6.1. They are all strongly connected to provide the intelligence, knowledge basis, and problem solving capabilities required for solving real design problems.

Design knowledge relates to all subjects required for problem solving. This may be either related to or independent on the problem at hand. Design skills are learned abilities to perform a design action or execute a process. Both of these result from experience. Design capabilities are required to perform a function; attitude is a way of thinking, while experience is acquired through actual observations of solving practical problems. All five capacities should be equally emphasised in the educational programs in order to develop design competence in future engineers and designers.

This paper will present the methodology of methods applied in the EGPR course and address important issues observed during the years of performing EGPR course and reflect on competences acquired by the students.

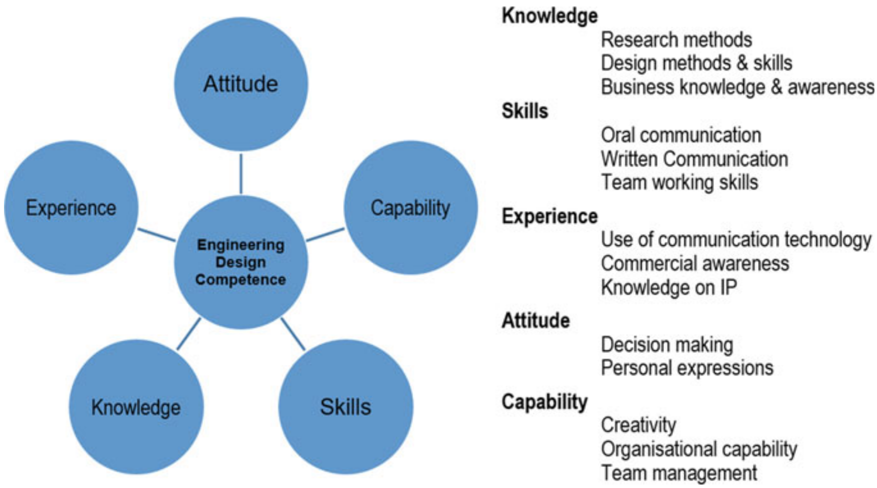

Fig. 6.1 Engineering Design Competence

6.2 History and Philosophy of E-GPR

European Global Product Realization course (EGPR) originally started as Global Product Realisation (GPR) by TU Delft, the Netherlands, University of Michigan, USA and Seoul National University, Korea in year 2000. It ran for two years but due to lack of tools for distributed synchronous communication and time differences between three continents was converted into a European project in 2002 (Horváth et al., 2004a, b), TU Delft, EPFL Lausanne, and University of Ljubljana joined to form the first project with the Slovenian company NIKO. Three more universities joined later, namely University of Zagreb in 2003, City, University of London in 2004, and University of Technology and Economics Budapest in 2009 (Kovacevic, 2016). In 2014, four European universities launched a joint educational project called NARIP (Networked Activities for Realization of Innovative Products). The project was supported by ERASMUS + funding (Vukasinovic, 2017). The history of University participants on the program is shown in Fig. 6.2. The project goal was to formalise, test and consolidate the methodology for collaborative new product development in a distributed environment by use of virtual tools.

In brief, each year participating Universities and an Industrial partner form an Academic Virtual Enterprise, as shown in the example from year 2018 in Fig. 6.3. Students are distributed in international teams formed from multiple partner Universities. The main communication comprising educational activities and project tasks is preformed through video-conferencing and other synchronous and asynchronous means of communication. The design process model applied in CODEVE originates from the model of Pahl and Beitz, but is extended and adapted to suit the fuzzy front end of design projects performed in academic virtual enterprises. The extensions are related to creating a vision and implementing design research methodologies at

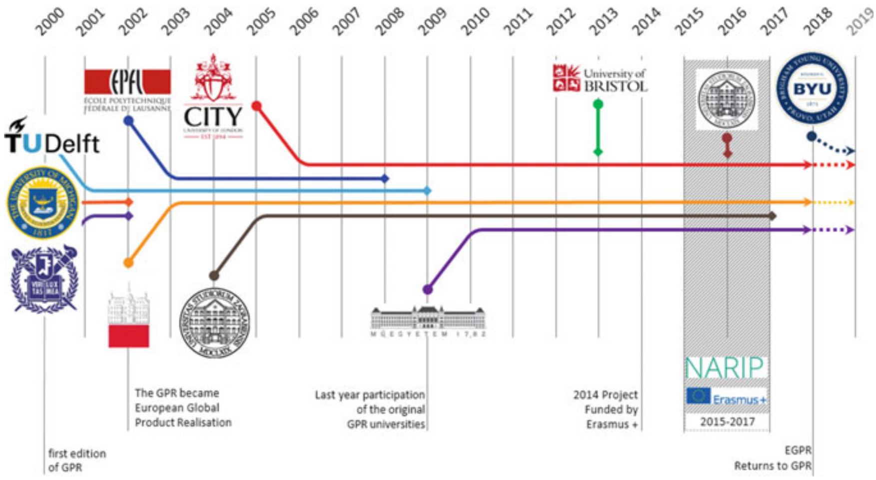

Fig. 6.2 Timeline showing milestones and University participants in the European global product realisation course

the start of the project, blending phases of embodiment and detail design as well as bringing students for the first time in the final workshop, which is aimed to culminate with the working prototype and public presentations of the products. The students are encouraged to perform conducted navigated active learning and include operational research in design process. At the end of the project, a hybrid prototype is assembled which often allows demonstration of IP generated for company.

The development of the teaching methodology was named CODEVE (Collaborative Design in Virtual Environment) and is explained in detail by Vidovics et al. (2016). The objective of the course is to expose students to effective methods in designing innovative products inside a distributed, collaborative, multidisciplinary, multinational and multicultural environment (Spinks et al., 2006) A wide variety of different projects with industrial partners have enabled a collection of broad and valuable insights and experiences over nearly two decades. The projects are unique each year and come from a variety of industrial sectors. They vary greatly in complexity, research and implementation as described by Pavkovic et al., 2011) and Kovacevic et al. (2016). The overview of the projects and partners participating in the EGPG course since 2008 is give in Fig. 6.4.

In 2017, the students' experiences in realising the NARIP project were summarised to evaluate suitability of the CODEVE teaching methodology for different disciplines and types of projects ranging from industrial design to engineering design. Tasks to design large industrial devices, like the welding inspection device for nuclear reactors from 2015, require a number of student groups to work on subsystems of a common prototype. On the other side, consumer products such as 2016's lighting solutions for aging population and 2017's lightweight mobility scooter require each student group to design and manufacture their own prototype. The first type of project is focused on engineering design while the second one leans

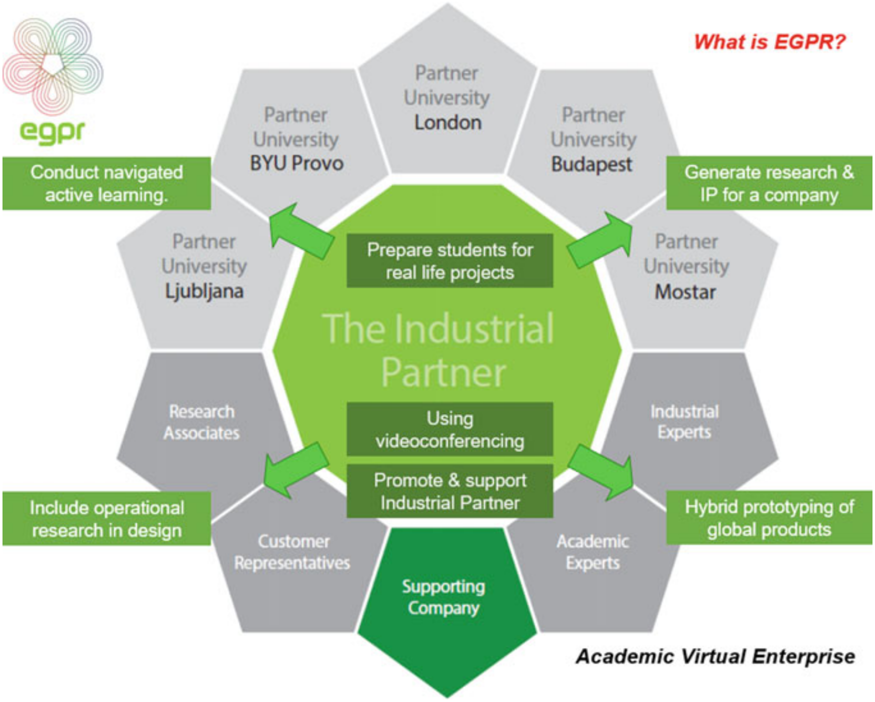

Fig. 6.3 Academic virtual enterprise of EGPR in 2018

towards industrial and product design. As shown in Kovacevic et al., (2017), it was confirmed that this teaching method was suitable for both and was ready for implementation in European collaborative projects. In 2018, a new partner, Brigham Young University from Provo in Utah, USA joined the EGPR community. Moreover, this year's industrial sponsor Black Diamond is based in Salt Lake City in Utah, USA and is a leader in outdoor climbing and skiing equipment. The project is hosted by City, University of London, marking the first time in the history of EGPR the partner company and the host university are not from the same country.

The next chapter will present a review of the effectiveness of the CODEVE methodology in this transatlantic project and expose the strengths and weaknesses of this methodology applied to teams consisting of industrial design, product design and engineering students collaborating within a globally distributed academic virtual environment.

Fig. 6.4 Project realised in the EGPR course since 2009

6.3 CODEVE Methodology

Research in design and engineering education has shown that the traditional engineering design practice is not sufficient anymore, as it cannot face and satisfy all the new design requirements within a reasonable design time frame. Collaborative design is emerging as a promising alternative to classical design approaches. Teams of students with multi-disciplinary, multi-national and multi-cultural background are formed to enable an in-depth view of design problems. Various institutions are participating in the concept-to-market design process, making it even more complex. Furthermore, the nature of teams has changed significantly because of changes in organizations and the nature of the work they do. These new conditions of the business environment, being rooted in globalization, the explosion of new technologies, economy based on knowledge, and the information era have made working in virtual teams a common approach for many organizations today. Higher education is not necessarily aware of the respective emerging knowledge, skill, or competence requirements, and which may not currently be satisfied. In particular, the challenges of student projects being carried out in virtual teams in remote collaboration need to be addressed, because these projects are not parts of the traditional designer curricula. All these issues challenge the HEIs to be able to adapt to this paradigm change in design setting, and also to satisfy the emerging and changing knowledge, skill, and competence needs of the current situation (Crain et al., 1995; Kovacevic, 2008). The above mentioned theoretical issues as well as many other practical ones have been addressed in a series of international product development courses EGPR. The EGPR course came to existence as an answer to the concept of borderless education as well as to the major trends in digitally-supported design such as (i) design across value chains (globalization of product development, realization and marketing), (ii) design across multiple domains (growing importance of integrated multi-disciplinary design), and (iii) designing across life cycle processes (from conceptualization, through production and utilization, to recycling). These are indicating the multiplicity of the aspects to be dealt with, the multi-faceted nature of the knowledge the students need to learn, and the complexity of the problem from an educational point of view. The professional content and didactic approach of the course were designed accordingly; the course applied two instructional streams, which are called professional navigation and industrial project, and followed a generic four-phase NPD model (Spinks et al., 2006). The series of lectures and presentations are provided for all participating students, and the industrial project is carried out in 5 or 6 international, multidisciplinary virtual teams, all working on an industrial assignment given by the selected industrial partner. From the project kick-off all parties communicate and collaborate by virtual means, yet the product realization (prototype fabrication and testing) and presentation is done at the site of the host university in the frame of a week-long workshop, where participants finally meet in person.

As it has been described previously, the know-how and methodology in this project based design course for collaborative new product development (NPD) in dislocated, virtual environment went through significant development and participating institutions and individuals gained a lot of knowledge and experience throughout the years. Therefore, CODEVE is definitely not without antecedents.

CODEVE methodology is indeed a refined and crystallized know-how to set up and successfully manage a NPD student project in industry-academia setting in a dislocated environment. The CODEVE methodology is the primary output of the first project year in the NARIP Erasmus + Strategic partnership project.

The research and methodology development activity here was three-fold. Firstly, the recent and latest experiences both with NPD and virtual collaboration in the partners' practices (mainly related to the EGPR) had to be studied and processed. Secondly, the state-of-the-art methodological developments had to be discovered and the possibilities of effective implementation had to be identified. Upon the findings and conclusions, and also on the niches found, a streamlined approach and methodology applicable in virtual environment was formulated. Thirdly, the models were tested and continuously adapted to design education in virtual environment. For this purpose, an experimental industry-academia project was carried out (i.e. the NARIP EGPR student project), which was the subject of seeking and finding the most critical points for further development both in theory and in practice.

6.3.1 Design Process Model

The design process model applied in the project originates from the model of Pahl et al., (1995) but in an extended, adapted version. The first phase, depending on the type of project may depart from Clarification of the task, and become more of a Fuzzy Front-End (FFE)-type of problem definition. Once the product is defined in terms of the demanded functions (and further requirements), teams could enter the concept generation phase. Another difference from the Pahl-Beitz model may be that there is no separate design phase for embodiment and detail design, with no intermediate review. The third major adjustment is that there is a prototype making phase at the end. Eventually, the design process resembles more closely the whole product development phase in the innovation model of Roozenburg and Eekels (1995). In the course methodology there are a number of guidelines and written aids available to ensure a common understanding in terms of the design process to follow. The goals, recommended tasks, and also expected outcomes and deliverables of each phase are prescribed in details. This, however, does not mean that the designers would be limited by obligatory methods and tools; in contrary, only the meeting points are defined to ensure the comparable outputs in time and depth, otherwise students are free to decide which way they choose. The process of developing and realising ideas in CODEVE methodology is shown in Fig. 6.5.

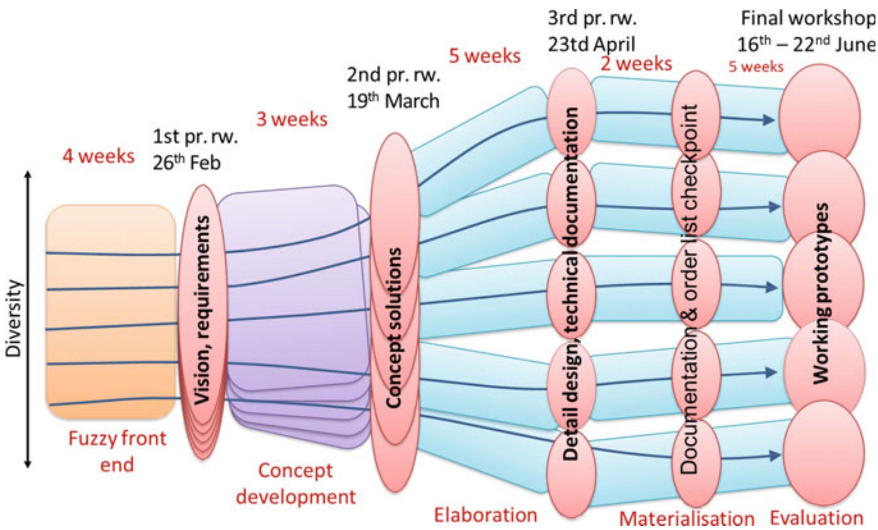

Fig. 6.5 CODEVE design process

6.3.2 Teams

In order to best simulate a real-life situation, the virtual enterprise of NARIP/EGPR acts like a flat-hierarchy virtual company, where the R&D and design departments are the student teams. The partner company is the customer, whereas academic staff takes only some higher level management roles, and otherwise facilitate interaction between company and student teams. The members of the teams are set before the project starts. Other than that, the team is an autonomous entity; it is responsible for setting up internal communication and working protocols, project and data management solutions, and definitely for the timely solution of the design assignment. Being a member of a dislocated international team, students might face challenges in language use or IT use, but most importantly, the greatest challenge is to actually perform as a team rather than eventually having the sum of individual efforts from remote locations. Within the team, not only the task distribution is important, but clear roles have to be set. This comes into focus, when the project assignment demands for a complex technical solution, where teams have to perform cross-team collaboration on top of internal team collaboration.

6.4 Project Preparation

6.4.1 Partners

For a successful project there has to be a sufficient number of partner universities involved, plus one industrial partner. As the partner company changes each year, they need to understand the philosophy and scheme of the project, for which there exist several written documents. In the early preparatory phases, the form and amount of contribution (material and immaterial) from company side has to be settled, while on the other hand the company expectations and possible benefits will also have to be clearly stated. IP rights are an issues that need to be addressed in advance as an agreement between industrial partner and organizing university on behalf of the whole project consortium. Further external, supporting and guesting partners could join the virtual enterprise, in the consensual agreement with the others. However, the most important contribution of the industrial partner is a document called Project Proposal. It is prepared by the company in collaboration with the host university, and in consensus with other partners. This document gives an overview of the aims and background of the project, briefly introduces partners, and most importantly the design challenge. The document specifies the project goals and expectations, recommends tasks to be performed by student teams, lists the deliverables with respective specifications, and also specifies phases, defining milestones with deadlines.

6.4.2 IT Communication and Collaborative Environment

The main means of communication and collaboration in a distributed environment are the Computer Supported Co-operative Work (CSCW) and Groupware solutions. Not surprisingly, the most widely used social platforms are utilised quite often to manage the teamwork. In terms of asynchronous collaboration in the course a few e-mailing lists are used, there is a shared workspace available for data exchange and backup. A whiteboard application is also available. The activities of joint problem solving (e.g. group ideation, common sketching, explaining and discussing the concepts, the discussion of needs for modification, common CAD modelling, etc.) are all still considered challenging, as even though the tools are available students may not be familiar with them. There has been a thorough document developed titled the "IT Guide", describing the official and optional IT solutions in details, furthermore there are chapters dedicated to proprieties and good practice in virtual environment.

6.5 Project Support

6.5.1 Academic Lectures and Professional Presentations

Although the EGPR project is aimed to be the final project for students before their employment in companies i.e. building on the already acquired knowledge, additional domain-specific lectures and topic-specific presentations are required to facilitate knowledge development. Academic lectures are delivered by renowned university staff, while professional presentations are held by external experts, professionals, and importantly, the representatives of the partner company. In terms of topics there are a variety of areas covered, e.g. project methodology and background, design methodology, relevant fields of engineering, management of virtual teams, CSCW solutions, creativity and innovation, presentation techniques, etc. In advance of the course start, the series of lectures and presentations are carefully planned in line with the logic and need of the current project and all are indicated in the Course schedule.

6.5.2 Coaching and Project Management

No project management can be successful without strict time management. The NARIP/EGPR timeline is specified with all details in a document called Course Calendar prior to the start of any student project activities. In this document, the course/project activities are broken down on a weekly basis. Two classes are scheduled every week via videoconferencing with defined titles, types of session, responsible location and a session moderator. Academic and professional lectures, student design review presentations, preparatory and consolidation meetings may use up the available timeslots.

The strict management of project and time is also crucial to synchronize the performance of the otherwise independent teams. Therefore, each virtual student team has a coach assigned (sometimes a co-coach as well), who is ideally an academic staff member with long coaching experience in student projects. The coach is essentially a point of reference; in the first place they enhance a common understanding in terms of tasks, duties, inputs, processes and the contents and form of delivery. The other major role of the coach is to monitor team activity and to point out underperforming or risks of failure well in advance. On the other hand, coaches and company representative in consensus with board of professors operationally manage the project. Coaches and company representative have regular weekly meetings (if necessary more frequently), to check the progress, evaluate the status against the work plan, and to analyze the possible risks on the level of the whole project. If necessary, these meetings can allow decisions to be made to initiate additional review points, prepare additional guidelines or protocols or apply shortcuts. This kind of continuous monitoring, quality control, and flexibility aims to realize the maximum effectiveness of all contributors and ensures that project goals are met successfully. In the project repository there are a number of documents and templates that can be used in different situations, however the management and quality assurance protocols are continuously evaluated and updated.

6.6 Project Closing

6.6.1 Closing Workshop

The project is 16–20 weeks long, and is divided into four phases according to the development process applied, each lasting 4–5 weeks, as shown in Fig. 6.5. The last phase, the Prototyping phase begins while teams are still operating in the distributed environment. It culminates with within the last project week (called the "Workshop week"), when all participants come together in the host country. The purpose of this co-located week is to assemble and test prototypes, and to present the project results to the academic staff, the company (generally located in the host country), and to a wider audience in a form of a large scale public presentation and exhibition. This is when the participants meet for the first time in person, which is always very motivating and a great experience. The peak point in the project is definitely the closing presentation and exhibition. This is a large scale event held at the host university campus. In practice, the closing day comprises of a series of presentation events. As EGPR is a university course, a formal academic-type presentation is required for final assessment and marking. A slightly different presentation is expected from student teams for company management with the emphasis adjusted to the interests of the audience. Testing of prototypes is carried out as a part of one of these presentations and it counts in the final assessment of students.

6.6.2 Scholarly Work

Throughout the years EGPR has provided a great opportunity to carry out experiments and research activities on each separate project. Besides having a distinct research focus in each year, the internal processes and phenomena were kept monitored by scientific quality methods. The latest findings and lessons learned are presented at relevant scientific conferences and journals. This activity serves dual goals; on one hand it significantly contributes to the quality assurance of the project, on the other hand it enables academics to extend their research work and research supervising activities both locally and within the EGPR community. After NARIP started, the approach has slightly changed. The main goal of the NARIP project was to consolidate and test a design education methodology for collaborative new product development in dislocated, virtual environment on variety of projects.

6.7 Projects Through Examples

The aims and objectives of companies collaborating on EGPR projects are different each year. This depends on the type of the business of the company, the sector in which the company operates, maturity of the company in terms of its position in the market and largely on the culture for NPD in the company. One of the objectives of NARIP and EGPR was to evaluate which type of product is the most suitable for this type of projects. Therefore.

6.7.1 Design of a Submersible Device for Inspection of Welds - Industrial Products

The NARIP 2015 was hosted by the University of Zagreb and the industrial partner INETEC - Institute for Nuclear Technology, both based in Zagreb, Croatia. For more than twenty years, INETEC has been a name synonymous for technological and service excellence in nuclear industry. They are active in research, development, design, construction and fabrication of equipment, tools, plugs and probes, including software and instruments for non-destructive examination.

In this project, students were faced with the challenging task of designing a remotely operated device for inspecting reactor pressure vessels in nuclear power

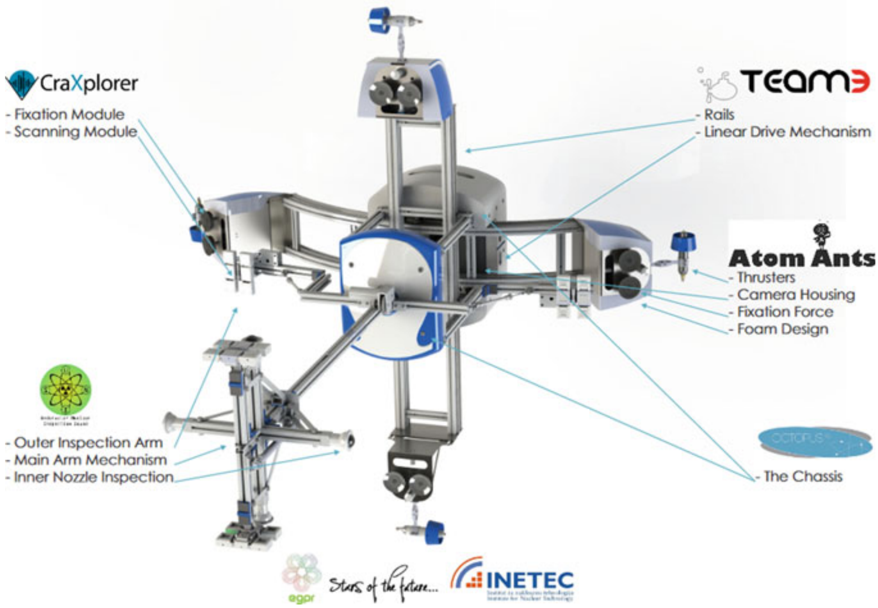

Fig. 6.6 Remotely operated device for inspecting welds in nuclear reactors, Zagreb, 2015

plants. Many aspects of the problem were investigated including; underwater propulsion, accurate location of vessel features, non-destructive testing methods and scanning procedures, power and data connections, and vehicle control. Total of 35 students from 4 universities were grouped in 5 international teams each focussed on a different subsystem as shown in Fig. 6.6. Students required excellent teamwork and communication in order to ensure compatibility between subsystems in the final prototype.

The week long workshop was hosted by the University of Zagreb in early July 2015. The assembly and testing of the single prototype was performed at INETEC facilities. The project demonstrated applicability of the CODEVE methodology for design of large devices for use in industry.

At the beginning of the project, students struggled to work collaboratively on this large device. This created a need for a cross-team and the update of instructions for different steps in CODEVE especially about the collaboration methods. Students used Conceptboard, an online whiteboard tool which proved to help both, in project management and communication.

Fig. 6.7 Design of intelligent lighting products for the ageing society, Budapest 2016

6.7.2 Design of Consumer Lighting Products in 2016 – Consumer Products

The host of NARIP 2016 was University of Technology and Economics from Budapest, Hungary. The project partner was Philips Lighting Hungary, subsidiary of Royal Philips of The Netherlands. The company is focused on improving people's lives through meaningful innovation in healthcare, consumer lifestyle and lighting. The project objective was 'Design of intelligent products for the challenges of the ageing society'. In this design assignment, the two most challenging areas are information sensing and processing related to visual and cognitive abilities respectively 39 students were grouped in 5 international teams. Each team developed their own vision which resulted in 5 working prototypes as shown in Fig. 6.7 (Vidovics et al., 2016). Prototypes ranged from the intelligent indoor gardening system to mood control lighting, heat detection system, intelligent stair lighting and stair climbing support systems.

6.7.3 Services Driven Products

The next type of products designed in this project are service driven products. The example is the project hosted by Technical University of Delft in collaboration with University Medical Centre from Utrecht in the Netherlands in 2009. Students had task to design devices for postoperative treatment of orthopaedic patients. Which will help patients and physicians in rehabilitation therapy. 32 students participated in the project and produced variety of solutions ranging from correcting posture of children to Wee technology to assess exercising and inform the consultant. As shown in Fig. 6.8, one of four groups designed product called Phoenix. It monitors the patient exercising at home. The docking station gives instructions on how to exercise. The patient puts markers on the specific locations on the body. The camera records the movement of the markers and the data is transmitted to the consultant

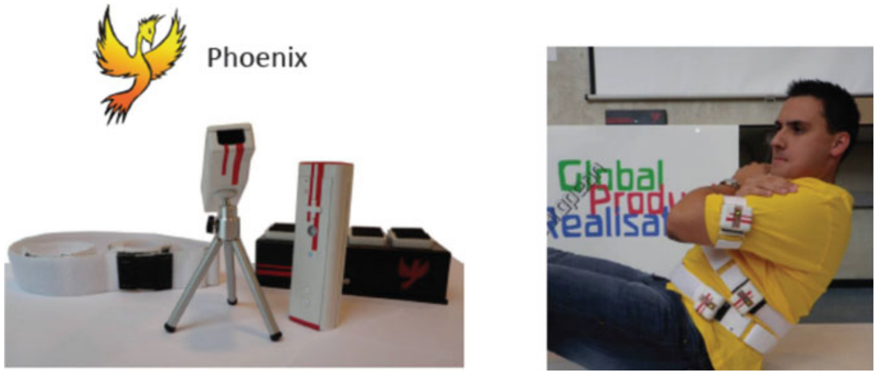

Fig. 6.8 Service based product UMC Utrecht, The Netherlands, 2009

over the internet. The consultant then can correct the patient and prescribe different exercises if required.

6.7.4 Fuzzy Front End Project

Most of the companies are open to innovation and allow students to start with completely open-ended projects. In the beginning, based on the project brief, students will create vision for personas of their choice and assess the social aspects of the product. Only in the later stages, with careful navigation from the company, the student will get in realisation of products and produce prototypes.

Figure 6.9 shows products and students participating in the transatlantic project in 2018 in which the Host University was City, University of London in the UK collaborating with Brigham Young University in Utah and BME from Budapest. The industrial partner was Utah based company Black diamond who asked students to design lighting solutions for outdoor activities. The students produced variety of interesting products.

6.8 Discussion

Surveys conducted in 2015 and 2016 established a benchmark for the analysis of projects in 2017 and 2018. The surveys were reasonably comprehensive and the full results were published in (Vukasinovic, 2017). Here we only present elements of the survey related to the project execution. In 2015 most students participated in the survey (33 of 35), while in 2016 only 30% of students returned the survey (12 of 39). The response to questions was given on the scale 0 to 5, 0 meaning ‘no influence’ with 5 meaning ‘heavy influence’. Despite the relatively low response rate in 2016,

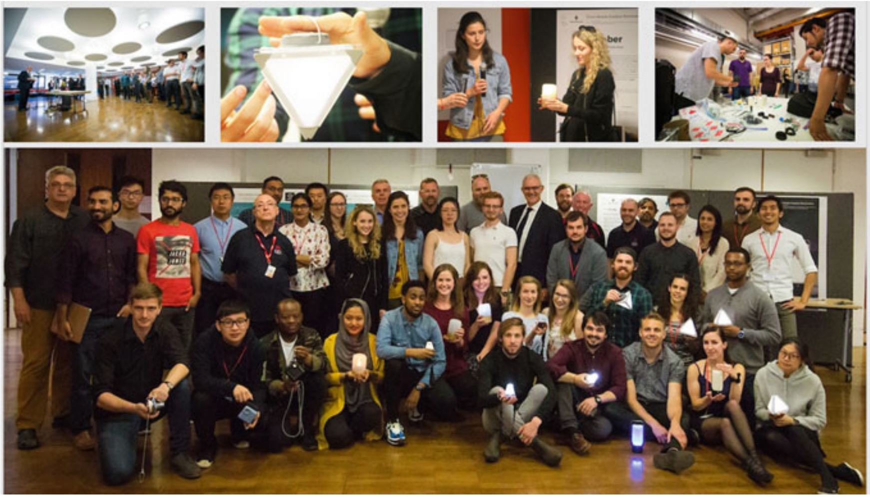

Fig. 6.9 Fuzzy front end project for black diamond, Utah, USA, 2018

the standard deviation for year 2016 was similar to that from 2015 and ranges from 0.5–1.1. Therefore the results were accepted as relevant.

Surveyed students felt that the level of achievement in 2016 when the project was about design of a relatively small consumer product is higher than for the industrial project performed in 2015. Students felt that the project objectives, target costs, and reduced complexity have been better achieved in 2016 when students worked one consumer products. This is probably because working on individual prototypes, students were able to have more control of the process and are more personally related to the final product. However, students felt that in both years the company goals were met but the achievement of company needs was overall lower than other individual criteria considered in this group of questions related to projects.

With regards to fulfilling the product specification set by students during the vision phase, it was shown that students who designed products for ageing population in 2016 were more satisfied with how their products matched specification. The complex product for industrial use designed in 2015 achieved only 70% of the target goals set in the vision phase. The consumer products in 2016 reached 90%. This shows that engagement of students in the project and their satisfaction with the results is better if such distributed design projects are related to consumer products. The supervision of the students and implementation of CODEVE methodology is also easier in this case. Although not subject of this study, the survey shows that it is easier for the academic staff to more directly implement CODEVE methodology for projects that address challenges of specific consumer groups through product design. The projects that focus on company engineering challenges are more challenging to realise.

The final part of the survey is related to how different factors affect student work in this international collaboration as shown in Fig. 6.10. Value 0 means no effect while value 5 means large effect. Results from both years are very similar. They show that the lowest impact on the project success is due to differences in cultural background of students. However the highest influence to students work and results is in the selection of design process and tools which are different in product and engineering deigns. For tasks related to consumer products, the selection of available tools is greater and the product design students can contribute more on aesthetics, ergonomics and user perception. Also, this requires engineering students to accept methods which they may not be using regularly in other design courses. Similarly, communication style, availability and clarity of shared information play crucial role in the realisation of the project. The improvements of CODEVE are possible in this area.

Another important factor is the availability of computer tools for implementation of CODEVE methodology. Nowadays, the tools for virtual communication are readily available and regularly used for social interactions and business. However not all of these tools are suitable for design projects and it is important to evaluate and improve CODEVE with respect to the new emerging communication technologies.

The next survey was performed in 2018. There were two reasons; firstly some changes were introduced in CODEVE especially in the fuzzy front end when the social aspect of the product design were emphasised and secondly because the project was performed with participation from USA and European Universities. In this study 53% of students (20 of 38) completed an online survey, in combination with randomized individual interviews with students. Results indicated that the process vocabulary differences between the different disciplines were more pronounced in 2018 than in

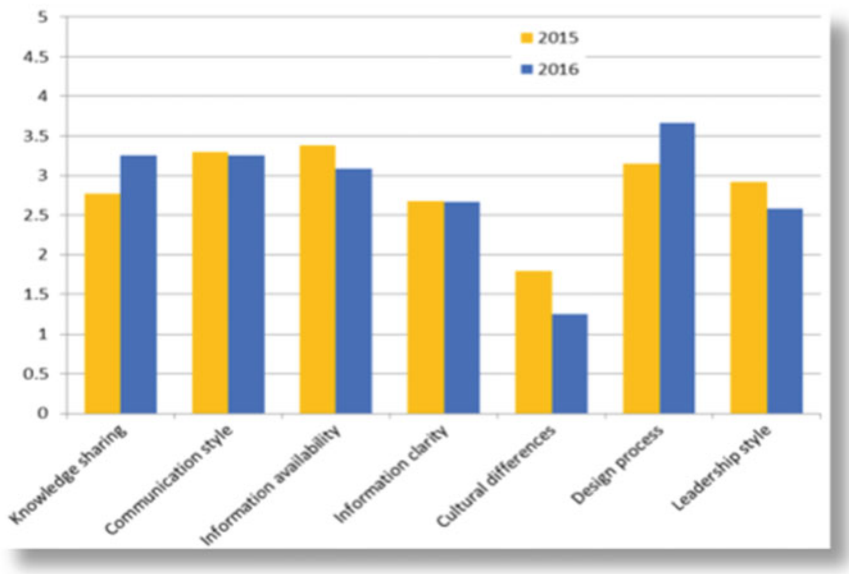

Fig. 6.10 Survey results for factors affecting team work using CODEVE

previous years when projects were organised within longer-term collaborating European University partners. While underlying goals were similar, there were frustrations as students tried to understand the vocabulary of other disciplines. Additionally, the general clarity of the fuzzy front-end methods and outcomes was low due to different starting times at three locations, London, Budapest and Utah with more than 3 weeks start between each university, causing issues transferring knowledge within teams. Documenting and presenting the work in different phases was also a challenge, as students are comfortable using virtual tools such as Google docs for asynchronous communication but are reluctant to use the blackboard-type system provided by the universities that allows monitoring of team progress. Varying methods of credit allotment between universities also caused stress as students discovered some disciplines valued certain phase components higher than the others, a phenomenon caused by deviance from the requirements of CODEVE methodology by the new-coming University. Finding common meeting times in 3 different time zones that are 7–8 h apart was also an enormous challenge; only one meeting with all participants took place in each phase. However, most students reported they either participated in or watched the majority of lectures and meetings as they were recorded and saved in the cloud for future viewing. Because students were distributed unevenly between universities, it is difficult to distribute tasks and follow the procedures evenly. Often team members from one university would meet and make decisions among themselves and neglect to share those decisions with team members in a timely manner, who continued operating on an outdated path.

A number of positive outcomes were also noted. The students enjoyed learning the processes and values of other disciplines and felt interdisciplinary collaboration creates more meaningful and complete products than individuals or single disciplines can. They also gained a respect for the challenges of working in different time zones, the importance of thoughtfully planning consequential communication, and the need to compromise and have patience with co-developers.

6.9 Conclusions

The framework of EGPR projects performed over 18 years by the Universities and companies from Europe and USA enabled development and demonstrated the applicability of the CODEVE methodology in a project based learning environment based on industry-academia collaboration. The teaching methodology for distributed Product Development courses presented in this chapter, illustrates details of the journey student take to achieve the desired final result of a new product development project—a full scale prototype, ready for testing and demonstration. CODEVE is not solely a university course description, nor simply an NPD methodology. From a different perspective it should be emphasized that this design course is one of a kind; here the R&D activities, the design and innovation processes and outputs are in good balance and just as important as the project itself, with all the project management considerations, the visibility of the project through the presentations and other PR activities, and the scientific publications.

Surveys conducted throughout the course showed the CODEVE methodology to be used for product design of industrial machinery and consumer products. Consumer related design projects are easier to manage and are more likely to meet the company project and product goals set by students through the 'voice of customers'. The selection of the design process, the communication style and the availability and quality of information are the most influential factors for the success of distributed design projects. New virtual tools are required for better implementation of CODEVE.

The re-introduction of transatlantic CODEVE project with participation of EU and USA partners was emotionally and cognitively polarizing, with students experiencing both elation and frustration with the course. The industrial and product design students were pushed beyond their traditional boundaries by including engineering practices that bring a product into a functional, operational reality. This will prove beneficial and distinguishing in their future employment applications. The engineering students were exposed to the values of a human-centred design process, the role of brand, and the importance of emotionally and functionally meaningful product designs, which will be equally useful for their future employment applications.

The CODEVE teaching methodology encourages students to understand and explore methods which they may not use regularly in their existing design courses. Similarly, communication style, relationship with teammates, and the availability and clarity of shared information play a crucial role in the realisation of the project. Such factors multiply the impact on student projects with participation from universities is different time zones, necessitating careful planning of process language and expectations, alignment of timing, simplification of tools and common understanding or phase deliverables for less dramatic transatlantic projects.

Acknowledgements The NARIP project 2015-2017 is a part of Erasmus+ Strategic Partnership program funded by the European Commission. This communication reflects the views of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein. Authors would like to thank the European Commission for the support in realising and evaluating CODEVE Methodology.

The Authors would also like to thank all participants in this project since it's inception in 2002. This includes more than 30 companies, More than 30 staff members from 12 participating Universities and over 800 students who participated in the project.

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